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# Matejcek Lake, Walsh County North Dakota

National Eutrophication Survey, Corvallis, Oreg

Prepared for

Corvallis Environmental Research Lab, Oreg

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# U.S. ENVIRONMENTAL PROTECTION AGENCY
# NATIONAL EUTROPHICATION SURVEY

**WORKING PAPER SERIES**

REPORT

ON

MATEJCEK LAKE

WALSH COUNTY

NORTH DAKOTA

EPA REGION VIII

WORKING PAPER No. 572

**CORVALLIS ENVIRONMENTAL RESEARCH LABORATORY - CORVALLIS, OREGON**

**and**

**ENVIRONMENTAL MONITORING & SUPPORT LABORATORY - LAS VEGAS, NEVADA**

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# REPORT
# ON
# MATEJCEK LAKE
# WALSH COUNTY
# NORTH DAKOTA
# EPA REGION VIII
# WORKING PAPER No. 572

WITH THE COOPERATION OF THE
NORTH DAKOTA STATE DEPARTMENT OF HEALTH
AND THE
NORTH DAKOTA NATIONAL GUARD
OCTOBER, 1976

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16. ABSTRACT

Annual total phosphorus and total nitrogen loadings to the lake were estimated and subdivided according to either point or non-point source origin. An assessment of the lake's trophic condition and limiting nutrient is also provided. All data collected by the U.S.E.P.A. National Eutrophication Survey during the one year study of the lake and its tributaries are included in the report.

17. KEY WORDS AND DOCUMENT ANALYSIS

| a. DESCRIPTORS | b. IDENTIFIERS/OPEN ENDED TERMS | c. COSATI Field/Group |
|---|---|---|
| eutrophication<br>lakes<br>nutrients<br>phosphorus<br>nitrogen<br>loading | | 05B<br>05C |

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# FOREWORD

The National Eutrophication Survey was initiated in 1972 in response to an Administration commitment to investigate the nationwide threat of accelerated eutrophication to freshwater lakes and reservoirs.

## OBJECTIVES

The Survey was designed to develop, in conjunction with state environmental agencies, information on nutrient sources, concentrations, and impact on selected freshwater lakes as a basis for formulating comprehensive and coordinated national, regional, and state management practices relating to point-source discharge reduction and non-point source pollution abatement in lake watersheds.

## ANALYTIC APPROACH

The mathematical and statistical procedures selected for the Survey's eutrophication analysis are based on related concepts that:

a. A generalized representation or model relating sources, concentrations, and impacts can be constructed.

b. By applying measurements of relevant parameters associated with lake degradation, the generalized model can be transformed into an operational representation of a lake, its drainage basin, and related nutrients.

c. With such a transformation, an assessment of the potential for eutrophication control can be made.

## LAKE ANALYSIS

In this report, the first stage of evaluation of lake and watershed data collected from the study lake and its drainage basin is documented. The report is formatted to provide state environmental agencies with specific information for basin planning [§303(e)], water quality criteria/standards review [§303(c)], clean lakes [§314(a,b)], and water quality monitoring [§106 and §305(b)] activities mandated by the Federal Water Pollution Control Act Amendments of 1972.

Beyond the single lake analysis, broader based correlations between nutrient concentrations (and loading) and trophic condition are being made to advance the rationale and data base for refinement of nutrient water quality criteria for the Nation's freshwater lakes. Likewise, multivariate evaluations for the relationships between land use, nutrient export, and trophic condition, by lake class or use, are being developed to assist in the formulation of planning guidelines and policies by EPA and to augment plans implementation by the states.

ACKNOWLEDGMENT

The staff of the National Eutrophication Survey (Office of Research & Development, U. S. Environmental Protection Agency) expresses sincere appreciation to the North Dakota State Department of Health for professional involvement, to the North Dakota National Guard for conducting the tributary sampling phase of the Survey, and to those North Dakota wastewater treatment plant operators who voluntarily provided effluent samples and flow data.

Norman L. Peterson, Director, and the staff of the Division of Water Supply and Pollution Control of the Department of Health, provided invaluable lake documentation and counsel during the Survey, reviewed the preliminary reports, and provided critiques most useful in the preparation of this Working Paper series.

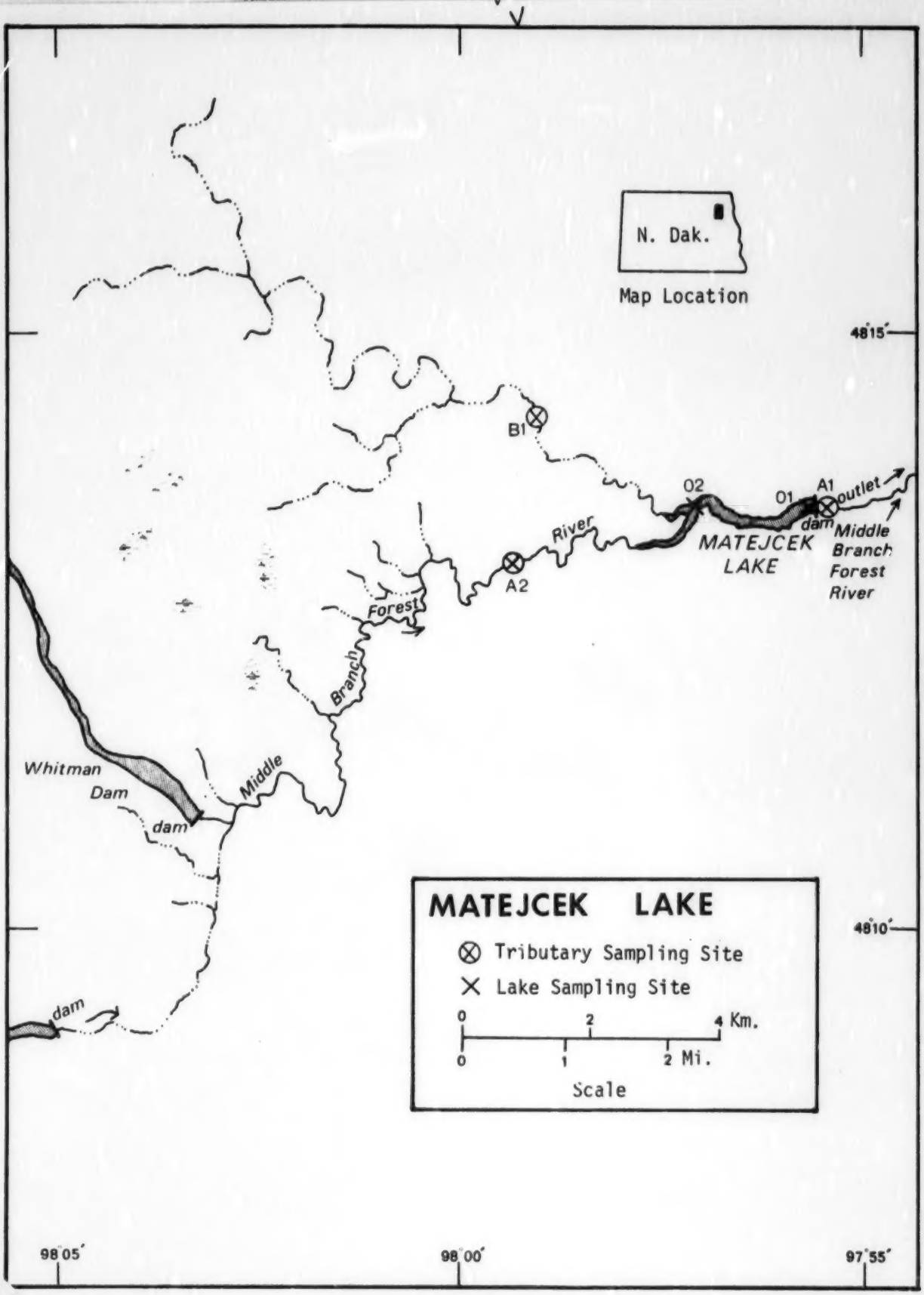
Major General LaClair A. Melhouse, the Adjutant General of North Dakota, and Project Officer Colonel Irvin M. Sande, who directed the volunteer efforts of the North Dakota National Guardsmen, are also gratefully acknowledged for their assistance to the Survey.

NATIONAL EUTROPHICATION SURVEY

STUDY LAKES AND RESERVOIRS

STATE OF NORTH DAKOTA

| NAME | COUNTY |
|---|---|
| Ashtabula | Barnes, Griggs |
| Audubon | McLean |
| Brush | McLean |
| Darling | Renville, Ward |
| Devils | Benson, Ramsey |
| Jamestown | Stutsman |
| LaMoure | LaMoure |
| Matejcek | Walsh |
| Metigoshe | Bottineau |
| Pelican | Bottineau |
| Sakakawea | Dunn, McKenzie, McLean, Mercer, Mountrail, Williams |
| Spiritwood | Stutsman |
| Sweet Briar | Morton |
| Whitman | Nelson, Walsh |


N. Dak.
Map Location
4815'
B1
O2
O1
A1
outlet
dam
Middle Branch Forest River
MATEJCEK LAKE
River
A2
Forest
Branch
Whitman Dam
dam
Middle
dam
MATEJCEK LAKE
Tributary Sampling Site
Lake Sampling Site
0 2 4 Km.
0 1 2 Mi.
Scale
4810'
98°05'
98°00'
97°55'

# MATEJCEK LAKE

## STORET NO. 3808

## I. CONCLUSIONS

### A. Trophic Condition:

Survey data indicate that Matejcek Lake is eutrophic. It ranked tenth in overall trophic quality when the 14 North Dakota lakes sampled in 1974 were compared using a combination of six lake parameters*. Eight of the lakes had less median total phosphorus, nine had less median dissolved orthophosphorus, 13 had less median inorganic nitrogen, none had less mean chlorophyll a, and 12 had greater mean Secchi disc transparency. Marked depression of dissolved oxygen with depth occurred at both sampling stations in April and July.

Survey limnologists noted surface concentrations of algae in July and September.

### B. Rate-Limiting Nutrient:

The algal assay results indicate that the lake was nitrogen limited in September. The lake data indicate nitrogen limitation at all sampling stations and times.

### C. Nutrient Controllability:

1. Point sources--No known point sources impacted Matejcek Lake during the sampling year.

---

* See Appendix A.

2. Non-point sources--Non-point sources contributed the entire phosphorus loading to the lake during the sampling year. The Middle Branch of the Forest River was the major source and contributed about 78% of the loading. Minor tributaries and immediate drainage contributed an estimated 21% of the loading.

The estimated phosphorus loading of 1.51 $g/m^2$/year is three times that proposed by Vollenweider (Vollenweider and Dillon, 1974) as a eutrophic loading (see page 11). A large reduction in this loading would be necessary to result in significant improvement in the trophic condition of the lake. However, since much of the phosphorus load is the result of agricultural practices (Peterson, 1974), this may be difficult to achieve.

## II. LAKE AND DRAINAGE BASIN CHARACTERISTICS†

### A. Lake Morphometry††:

1. Surface area: 0.53 kilometers$^2$.
2. Mean depth: 4.2 meters.
3. Maximum depth: 12.2 meters.
4. Volume: $2.226 \times 10^6$ m$^3$.
5. Mean hydraulic retention time: 236 days.

### B. Tributary and Outlet:
(See Appendix C for flow data)

1. Tributaries -

| Name | Drainage area (km$^2$)* | Mean flow (m$^3$/sec)* |
|---|---|---|
| Middle Branch Forest River | 176.1 | 0.081 |
| Minor tributaries & immediate drainage - | 51.3 | 0.026 |
| Totals | 227.4 | 0.107 |

2. Outlet -

| | | |
|---|---|---|
| Middle Branch Forest River | 227.9** | 0.109 |

### C. Precipitation***:

1. Year of sampling: 31.7 centimeters.
2. Mean annual: 44.7 centimeters.

---

† Table of metric conversions--Appendix B.
†† Henegar, 1975.
* For limits of accuracy, see Working Paper No. 175, "...Survey Methods, 1973-1976".
** Includes area of lake.
*** See Working Paper No. 175.

## III. LAKE WATER QUALITY SUMMARY

Matejcek Lake was sampled three times during the open-water season of 1974 by means of a pontoon-equipped Huey helicopter. Each time, samples for physical and chemical parameters were collected from a number of depths at two stations on the lake (see map, page v). During each visit, a single depth-integrated (4.6 m to surface) sample was composited from the stations for phytoplankton identification and enumeration; and during the last visit, a single 18.9-liter depth-integrated sample was composited for algal assays. Also each time, a depth-integrated sample was collected from each of the stations for chlorophyll *a* analysis. The maximum depths sampled were 11.3 meters at station 1 and 7.6 meters at station 2.

The sampling results are presented in full in Appendix D and are summarized in the following table.

A. SUMMARY OF PHYSICAL AND CHEMICAL CHARACTERISTICS FOR MATEJCEK LAKE
STORET CODE 3808

| PARAMETER | 1ST SAMPLING ( 4/29/74) 2 SITES RANGE | MEAN | MEDIAN | 2ND SAMPLING ( 7/16/74) 2 SITES RANGE | MEAN | MEDIAN | 3RD SAMPLING ( 9/16/74) 2 SITES RANGE | MEAN | MEDIAN |
|---|---|---|---|---|---|---|---|---|---|
| TEMP (C) | 3.1 - 7.9 | 6.1 | 6.8 | 10.9 - 24.5 | 19.6 | 22.4 | 13.6 - 15.0 | 14.2 | 14.3 |
| DISS OXY (MG/L) | 2.0 - 8.6 | 6.4 | 7.1 | 0.6 - 7.0 | 4.1 | 6.2 | 7.2 - 8.0 | 7.7 | 7.8 |
| CNDCTVY (MCROMO) | 268. - 356. | 297. | 284. | 360. - 522. | 464. | 505. | 395. - 417. | 403. | 403. |
| PH (STAND UNITS) | 7.3 - 7.7 | 7.5 | 7.5 | 8.0 - 8.7 | 8.3 | 8.3 | 8.0 - 8.2 | 8.1 | 8.0 |
| TOT ALK (MG/L) | 108. - 204. | 136. | 117. | 152. - 170. | 163. | 165. | 169. - 179. | 174. | 175. |
| TOT P (MG/L) | 0.233 - 0.312 | 0.272 | 0.279 | 0.181 - 0.261 | 0.222 | 0.228 | 0.176 - 0.228 | 0.191 | 0.187 |
| ORTHO P (MG/L) | 0.204 - 0.225 | 0.214 | 0.216 | 0.155 - 0.215 | 0.181 | 0.179 | 0.115 - 0.145 | 0.130 | 0.129 |
| NO2+NO3 (MG/L) | 0.830 - 1.410 | 1.270 | 1.355 | 0.220 - 0.740 | 0.364 | 0.280 | 0.060 - 0.060 | 0.060 | 0.060 |
| AMMONIA (MG/L) | 0.230 - 0.260 | 0.247 | 0.250 | 0.090 - 0.290 | 0.147 | 0.130 | 0.270 - 0.310 | 0.295 | 0.300 |
| KJEL N (MG/L) | 1.100 - 1.200 | 1.125 | 1.100 | 0.700 - 1.100 | 0.886 | 0.900 | 1.100 - 1.600 | 1.212 | 1.200 |
| INORG N (MG/L) | 1.090 - 1.660 | 1.517 | 1.595 | 0.340 - 0.830 | 0.511 | 0.440 | 0.330 - 0.370 | 0.355 | 0.360 |
| TOTAL N (MG/L) | 2.030 - 2.580 | 2.395 | 2.455 | 0.920 - 1.540 | 1.250 | 1.240 | 1.160 - 1.660 | 1.272 | 1.260 |
| CHLRPYL A (UG/L) | 1.9 - 2.2 | 2.0 | 2.0 | 2.3 - 2.7 | 2.5 | 2.5 | 3.2 - 3.8 | 3.5 | 3.5 |
| SECCHI (METERS) | 0.5 - 0.5 | 0.5 | 0.5 | 0.9 - 0.9 | 0.9 | 0.9 | 0.4 - 0.6 | 0.5 | 0.5 |

B. Biological Characteristics:

1. Phytoplankton -

| Sampling Date | Dominant Genera | Algal Units per ml |
|---|---|---|
| 04/29/74 | 1. Cryptomonas sp. | 116 |
| | 2. Chlamydomonas sp. | 93 |
| | 3. Gymnodinium sp. | 47 |
| | 4. Ankistrodesmus sp. | 23 |
| | Total | 279 |
| 07/16/74 | 1. Scenedesmus sp. | 18 |
| | 2. Sphaerocystis sp. | 18 |
| | 3. Aphanizomenon sp. | 18 |
| | Total | 54 |
| 09/16/74 | 1. Flagellates | 135 |
| | 2. Cryptomonas sp. | 68 |
| | 3. Aphanizomenon sp. | 68 |
| | Total | 271 |

2. Chlorophyll a -

| Sampling Date | Station Number | Chlorophyll a (µg/l) |
|---|---|---|
| 04/29/74 | 1 | 2.2 |
| | 2 | 1.9 |
| 07/16/74 | 1 | 2.3 |
| | 2 | 2.7 |
| 09/16/74 | 1 | 3.2 |
| | 2 | 3.8 |

C. Limiting Nutrient Study:

1. Autoclaved, filtered, and nutrient spiked -

| Spike (mg/l) | Ortho P Conc. (mg/l) | Inorganic N Conc. (mg/l) | Maximum yield (mg/l-dry wt.) |
|---|---|---|---|
| Control | 0.125 | 0.334 | 11.2 |
| 0.050 P | 0.175 | 0.334 | 8.1 |
| 0.050 P + 1.0 N | 0.175 | 1.334 | 37.3 |
| 1.0 N | 0.125 | 1.334 | 34.7 |

2. Discussion -

The control yield of the assay alga, Selenastrum capricornutum, indicates that the potential primary productivity of Matejcek Lake was very high at the time the assay sample was collected (09/16/74). Also, a significant increase in yield with the addition of nitrogen alone indicates that the lake was limited by nitrogen at that time. Note that the addition of phosphorus alone did not result in a yield greater than the control yield.

The lake data are also indicative of nitrogen limitation; i.e., the mean inorganic nitrogen/orthophosphorus ratios were 7/1 or less on all sampling occasions.

## IV. NUTRIENT LOADINGS
(See Appendix E for data)

For the determination of nutrient loadings, when possible the North Dakota National Guard collected monthly near-surface grab samples from each of the tributary sites indicated on the map (page v), except for the high runoff month of May when two samples were collected. Sampling was begun in September, 1974, and was completed in August, 1975.

Through an interagency agreement, stream flow estimates for the year of sampling and a "normalized" or average year were provided by the North Dakota District Office of the U.S. Geological Survey for the tributary sites nearest the lake.

In this report, nutrient loads for sampled tributaries were calculated using mean annual concentrations and mean annual flows. Nutrient loads for unsampled "minor tributaries and immediate drainage" ("ZZ" of U.S.G.S.) were estimated using the mean concentrations in the Middle Branch Forest River at station A-2 and the mean annual ZZ flow.

A. Waste Sources:

1. Known municipal - None
2. Known industrial - None

B. Annual Total Phosphorus Loading - Average Year:

1. Inputs -

| Source | kg P/ yr | % of total |
|---|---|---|
| a. Tributaries (non-point load) - | | |
| Middle Branch Forest River | 600 | 75.0 |
| b. Minor tributaries & immediate drainage (non-point load) - | 190 | 23.7 |
| c. Known municipal STP's - None | - | - |
| d. Septic tanks - None | - | - |
| e. Known industrial - None | - | - |
| f. Direct precipitation* - | 10 | 1.3 |
| Total | 800 | 100.0 |

2. Outputs -

| | |
|---|---|
| Lake outlet - Middle Branch Forest River | 510 |

3. Net annual P accumulation - 290 kg.

* See Working Paper No. 175.

C. Annual Total Nitrogen Loading - Average Year:

1. Inputs -

| Source | kg N/yr | % of total |
|---|---|---|
| a. Tributaries (non-point load) - | | |
| Middle Branch Forest River | 5,210 | 69.9 |
| b. Minor tributaries & immediate drainage (non-point load) - | 1,670 | 22.4 |
| c. Known municipal STP's - None | - | - |
| d. Septic tanks - None | - | - |
| e. Known industrial - None | - | - |
| f. Direct precipitation* - | 570 | 7.7 |
| Total | 7,450 | 100.0 |

2. Outputs -

| | |
|---|---|
| Lake outlet - Middle Branch Forest River | 7,320 |

3. Net annual N accumulation - 130 kg.

D. Non-point Nutrient Export by Subdrainage Area:

| Tributary | kg P/km$^2$/yr | kg N/km$^2$/yr |
|---|---|---|
| Middle Branch Forest River | 3 | 30 |

E. Mean Nutrient Concentrations in Ungaged Stream:

| Tributary | Mean Total P Conc. (mg/l) | Mean Total N Conc. (mg/l) |
|---|---|---|
| Unnamed Creek B-1 | 0.122 | 2.987 |

* See Working Paper No. 175.

F. Yearly Loads:

In the following table, the existing phosphorus loadings are compared to those proposed by Vollenweider (Vollenweider and Dillon, 1974). Essentially, his "dangerous" loading is one at which the receiving water would become eutrophic or remain eutrophic; his "permissible" loading is that which would result in the receiving water remaining oligotrophic or becoming oligotrophic if morphometry permitted. A mesotrophic loading would be considered one between "dangerous" and "permissible".

Note that Vollenweider's model may not be applicable to water bodies with short hydraulic retention times.

| | Total Phosphorus | | Total Nitrogen | |
|---|---|---|---|---|
| | Total | Accumulated | Total | Accumulated |
| grams/$m^2$/yr | 1.51 | 0.55 | 14.1 | 0.2 |

Vollenweider phosphorus loadings ($g/m^2/yr$) based on mean depth and mean hydraulic retention time of Matejcek Lake:

| | |
|---|---|
| "Dangerous" (eutrophic loading) | 0.50 |
| "Permissible" (oligotrophic loading) | 0.25 |

## V. LITERATURE REVIEWED

Henegar, Dale, 1975. Personal communication (lake morphometry). ND Game & Fish Dept., Bismarck.

Peterson, Norman L., 1974. Personal communication (nutrient sources in the Matejcek Lake drainage basin). ND Dept. of Health, Bismarck.

Vollenweider, R. A., and P. J. Dillon, 1974. The application of the phosphorus loading concept to eutrophication research. Natl. Res. Council of Canada Publ. No. 13690, Canada Centre for Inland Waters, Burlington, Ontario.

# VI. APPENDICES

## APPENDIX A

## LAKE RANKINGS

PERCENT OF LAKES WITH HIGHER VALUES (NUMBER OF LAKES WITH HIGHER VALUES)

| LAKE CODE | LAKE NAME | MEDIAN TOTAL P | MEDIAN INORG N | 500-MEAN SEC | MEAN CHLORA | 15-MIN DO | MEDIAN DISS ORTHO P | INDEX NO |
|---|---|---|---|---|---|---|---|---|
| 3801 | LAKE ASHTABULA | 27 ( 3) | 54 ( 7) | 15 ( 2) | 8 ( 1) | 62 ( 8) | 38 ( 5) | 204 |
| 3802 | LAKE AUDUBON | 69 ( 9) | 46 ( 6) | 46 ( 6) | 69 ( 9) | 46 ( 6) | 69 ( 9) | 345 |
| 3803 | BRUSH LAKE | 77 ( 10) | 77 ( 10) | 38 ( 5) | 38 ( 5) | 81 ( 10) | 81 ( 10) | 392 |
| 3804 | LAKE DARLING | 15 ( 2) | 38 ( 5) | 23 ( 3) | 0 ( 0) | 38 ( 5) | 23 ( 3) | 137 |
| 3805 | DEVILS LAKE | 0 ( 0) | 69 ( 9) | 31 ( 4) | 23 ( 3) | 15 ( 2) | 0 ( 0) | 138 |
| 3806 | JAMESTOWN RESERVOIR | 54 ( 7) | 15 ( 2) | 62 ( 8) | 62 ( 8) | 96 ( 12) | 54 ( 7) | 343 |
| 3807 | LAKE LA MOURE | 8 ( 1) | 8 ( 1) | 69 ( 9) | 54 ( 7) | 4 ( 0) | 8 ( 1) | 151 |
| 3808 | MATEJCEK LAKE | 38 ( 5) | 0 ( 0) | 8 ( 1) | 100 ( 13) | 23 ( 3) | 31 ( 4) | 200 |
| 3809 | LAKE METIGOSHE | 92 ( 12) | 92 ( 12) | 92 ( 12) | 85 ( 11) | 81 ( 10) | 81 ( 10) | 523 |
| 3811 | PELICAN LAKE | 85 ( 11) | 100 ( 13) | 100 ( 13) | 77 ( 10) | 31 ( 4) | 100 ( 13) | 493 |
| 3812 | LAKE SAKAKAWEA (GARRISON | 100 ( 13) | 62 ( 8) | 85 ( 11) | 92 ( 12) | 54 ( 7) | 92 ( 12) | 485 |
| 3813 | SPIRIT WOOD LAKE | 46 ( 6) | 23 ( 3) | 77 ( 10) | 31 ( 4) | 4 ( 0) | 46 ( 6) | 227 |
| 3814 | SWEET BRIAR RESERVOIR | 62 ( 8) | 85 ( 11) | 54 ( 7) | 15 ( 2) | 96 ( 12) | 62 ( 8) | 374 |
| 3815 | WHITMAN LAKE | 27 ( 3) | 31 ( 4) | 0 ( 0) | 46 ( 6) | 69 ( 9) | 15 ( 2) | 188 |

LAKE DATA TO BE USED IN RANKINGS

| LAKE CODE | LAKE NAME | MEDIAN TOTAL P | MEDIAN INORG N | 500-MEAN SEC | MEAN CHLORA | 15-MIN DO | MEDIAN DISS ORTHO P |
|---|---|---|---|---|---|---|---|
| 3801 | LAKE ASHTABULA | 0.260 | 0.160 | 472.250 | 40.892 | 10.600 | 0.170 |
| 3802 | LAKE AUDUBON | 0.087 | 0.220 | 446.222 | 11.322 | 11.000 | 0.015 |
| 3803 | BRUSH LAKE | 0.066 | 0.095 | 449.143 | 29.114 | 9.000 | 0.010 |
| 3804 | LAKE DARLING | 0.274 | 0.250 | 466.750 | 60.075 | 11.600 | 0.180 |
| 3805 | DEVILS LAKE | 0.630 | 0.140 | 449.333 | 38.508 | 14.600 | 0.469 |
| 3806 | JAMESTOWN RESERVOIR | 0.144 | 0.365 | 438.667 | 19.400 | 8.800 | 0.076 |
| 3807 | LAKE LA MOURE | 0.438 | 0.380 | 421.400 | 19.720 | 15.000 | 0.290 |
| 3808 | MATEJCEK LAKE | 0.228 | 0.440 | 475.167 | 2.683 | 14.400 | 0.179 |
| 3809 | LAKE METIGOSHE | 0.032 | 0.080 | 389.167 | 10.367 | 9.000 | 0.010 |
| 3811 | PELICAN LAKE | 0.034 | 0.070 | 364.500 | 10.950 | 12.800 | 0.006 |
| 3812 | LAKE SAKAKAWEA (GARRISON | 0.016 | 0.150 | 408.733 | 6.883 | 10.800 | 0.007 |
| 3813 | SPIRIT WOOD LAKE | 0.156 | 0.290 | 417.833 | 34.667 | 15.000 | 0.082 |
| 3814 | SWEET BRIAR RESERVOIR | 0.092 | 0.090 | 440.800 | 39.000 | 8.800 | 0.031 |
| 3815 | WHITMAN LAKE | 0.260 | 0.260 | 478.333 | 27.067 | 9.200 | 0.185 |

LAKES RANKED BY INDEX NOS.

| RANK | LAKE CODE | LAKE NAME | INDEX NO |
|---|---|---|---|
| 1 | 3809 | LAKE METIGOSHE | 523 |
| 2 | 3811 | PELICAN LAKE | 493 |
| 3 | 3812 | LAKE SAKAKAWEA (GARRISON | 485 |
| 4 | 3803 | BRUSH LAKE | 392 |
| 5 | 3814 | SWEET BRIAR RESERVOIR | 374 |
| 6 | 3802 | LAKE AUDUBON | 345 |
| 7 | 3806 | JAMESTOWN RESERVOIR | 343 |
| 8 | 3813 | SPIRIT WOOD LAKE | 227 |
| 9 | 3801 | LAKE ASHTABULA | 204 |
| 10 | 3808 | MATEJCEK LAKE | 200 |
| 11 | 3815 | WHITMAN LAKE | 188 |
| 12 | 3807 | LAKE LA MOURE | 151 |
| 13 | 3805 | DEVILS LAKE | 138 |
| 14 | 3804 | LAKE DARLING | 137 |

# APPENDIX B

## CONVERSION FACTORS

## CONVERSION FACTORS

Hectares x 2.471 = acres

Kilometers x 0.6214 = miles

Meters x 3.281 = feet

Cubic meters x $8.107 \times 10^{-4}$ = acre/feet

Square kilometers x 0.3861 = square miles

Cubic meters/sec x 35.315 = cubic feet/sec

Centimeters x 0.3937 = inches

Kilograms x 2.205 = pounds

Kilograms/square kilometer x 5.711 = lbs/square mile

# APPENDIX C

## TRIBUTARY FLOW DATA

TRIBUTARY FLOW INFORMATION FOR NORTH DAKOTA 03/16/76

LAKE CODE 3808 MATEJEK RESERVOIR

TOTAL DRAINAGE AREA OF LAKE(SQ KM) 227.9

| TRIBUTARY | SUB-DRAINAGE AREA(SQ KM) | NORMALIZED FLOWS(CMS) JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC | MEAN |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3808A1 | 227.9 | 0.0 | 0.0 | 0.198 | 0.566 | 0.227 | 0.142 | 0.085 | 0.028 | 0.020 | 0.017 | 0.017 | 0.011 | 0.109 |
| 3808A2 | 176.1 | 0.003 | 0.003 | 0.113 | 0.425 | 0.170 | 0.113 | 0.071 | 0.023 | 0.014 | 0.014 | 0.014 | 0.008 | 0.081 |
| 3808ZZ | 77.7 | 0.0 | 0.0 | 0.045 | 0.136 | 0.057 | 0.028 | 0.023 | 0.006 | 0.003 | 0.003 | 0.003 | 0.003 | 0.026 |

SUMMARY

TOTAL DRAINAGE AREA OF LAKE = 227.9
SUM OF SUB-DRAINAGE AREAS = 253.8

TOTAL FLOW IN = 1.28
TOTAL FLOW OUT = 1.31

MEAN MONTHLY FLOWS AND DAILY FLOWS(CMS)

| TRIBUTARY | MONTH | YEAR | MEAN FLOW | DAY | FLOW | DAY | FLOW | DAY | FLOW |
|---|---|---|---|---|---|---|---|---|---|
| 3808A1 | 9 | 74 | 0.001 | 21 | 0.001 | | | | |
| | 10 | 74 | 0.001 | 21 | 0.001 | | | | |
| | 11 | 74 | 0.001 | 21 | 0.001 | | | | |
| | 12 | 74 | 0.001 | 21 | 0.001 | | | | |
| | 1 | 75 | 0.001 | 18 | 0.001 | | | | |
| | 2 | 75 | 0.001 | 23 | 0.001 | | | | |
| | 3 | 75 | 0.001 | 24 | 0.001 | | | | |
| | 4 | 75 | 0.028 | 5 | 0.001 | 20 | 0.001 | | |
| | 5 | 75 | 0.340 | 4 | 0.991 | 20 | 0.142 | | |
| | 6 | 75 | 0.020 | 23 | 0.014 | | | | |
| | 7 | 75 | 0.311 | 21 | 0.198 | | | | |
| | 8 | 75 | 0.008 | 23 | 0.001 | | | | |
| 3808A2 | 9 | 74 | 0.0 | 21 | 0.0 | | | | |
| | 10 | 74 | 0.0 | 21 | 0.0 | | | | |
| | 11 | 74 | 0.0 | 21 | 0.0 | | | | |
| | 12 | 74 | 0.0 | 21 | 0.0 | | | | |
| | 1 | 75 | 0.0 | 18 | 0.0 | | | | |
| | 2 | 75 | 0.0 | 23 | 0.0 | | | | |
| | 3 | 75 | 0.028 | 24 | 0.0 | | | | |
| | 4 | 75 | 0.164 | 6 | 0.0 | 20 | 0.198 | | |
| | 5 | 75 | 0.340 | 4 | 0.991 | 20 | 0.034 | | |
| | 6 | 75 | 0.008 | 23 | 0.017 | | | | |
| | 7 | 75 | 0.269 | 21 | 0.142 | | | | |
| | 8 | 75 | 0.002 | 23 | 0.001 | | | | |
| 3808ZZ | 9 | 74 | 0.0 | | | | | | |
| | 10 | 74 | 0.0 | | | | | | |
| | 11 | 74 | 0.0 | | | | | | |
| | 12 | 74 | 0.0 | | | | | | |
| | 1 | 75 | 0.0 | | | | | | |
| | 2 | 75 | 0.0 | | | | | | |
| | 3 | 75 | 0.0 | | | | | | |
| | 4 | 75 | 0.113 | | | | | | |
| | 5 | 75 | 0.057 | | | | | | |
| | 6 | 75 | 0.008 | | | | | | |
| | 7 | 75 | 0.085 | | | | | | |
| | 8 | 75 | 0.0 | | | | | | |

# APPENDIX D

## PHYSICAL and CHEMICAL DATA

STORET RETRIEVAL DATE 76/03/16

380801
48 13 28.0 097 57 00.0 4
MATEJCEK LAKE
38099 NORTH DAKOTA

11EPALES 2111202
0042 FEET DEPTH CLASS 00

| DATE FROM TO | TIME OF DAY | DEPTH FEET | 00010 WATER TEMP CENT | 00300 DO MG/L | 00077 TRANSP SECCHI INCHES | 00094 CNDUCTVY FIELD MICROMHO | 00400 PH SU | 00410 T ALK CACO3 MG/L | 00610 NH3-N TOTAL MG/L | 00625 TOT KJEL N MG/L | 00630 NO2&NO3 N-TOTAL MG/L | 00671 PHOS-DIS ORTHO MG/L P |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 74/04/29 | 11 | 00 0000 | 7.3 | | 20 | 268 | 7.65 | 109 | 0.260 | 1.100 | 1.400 | 0.221 |
| | 11 | 00 0005 | 7.3 | 8.4 | | 269 | 7.60 | 112 | 0.240 | 1.100 | 1.380 | 0.225 |
| | 11 | 00 0015 | 5.7 | 7.2 | | 295 | 7.50 | 136 | 0.230 | 1.100 | 1.330 | 0.217 |
| | 11 | 00 0037 | 3.1 | 2.0 | | 356 | 7.35 | 204 | 0.260 | 1.200 | 0.830 | 0.206 |
| 74/07/16 | 13 | 30 0000 | 23.0 | 7.0 | 36 | 506 | 8.50 | 165 | 0.130 | 1.000 | 0.240 | 0.155 |
| | 13 | 30 0005 | 22.4 | 6.2 | | 505 | 8.70 | 161 | 0.120 | 0.700 | 0.220 | 0.204 |
| | 13 | 30 0015 | 15.8 | 0.6 | | 407 | 8.00 | 158 | 0.090 | 0.900 | 0.460 | 0.196 |
| | 13 | 30 0030 | 10.9 | 0.6 | | 360 | 8.00 | 152 | 0.090 | 0.800 | 0.740 | 0.215 |
| 74/09/16 | 13 | 25 0000 | 15.0 | 8.0 | 24 | 417 | 8.23 | 179 | 0.300 | 1.600 | 0.060 | 0.144 |
| | 13 | 25 0010 | 14.4 | 8.0 | | 403 | 8.09 | 169 | 0.280 | 1.200 | 0.060 | 0.122 |
| | 13 | 25 0015 | 14.4 | 7.9 | | 405 | 8.13 | 172 | 0.280 | 1.100 | 0.060 | 0.138 |
| | 13 | 25 0031 | 14.3 | 7.8 | | 403 | 8.17 | 175 | 0.270 | 1.200 | 0.060 | 0.145 |

| DATE FROM TO | TIME OF DAY | DEPTH FEET | 00665 PHOS-TOT MG/L P | 32217 CHLRPHYL A UG/L | 00031 INCDT LT REMNING PERCENT |
|---|---|---|---|---|---|
| 74/04/29 | 11 | 00 0000 | 0.285 | 2.2 | |
| | 11 | 00 0005 | 0.289 | | |
| | 11 | 00 0015 | 0.259 | | |
| | 11 | 00 0037 | 0.233 | | |
| 74/07/16 | 13 | 30 0000 | 0.181 | 2.3 | |
| | 13 | 30 0005 | 0.226 | | |
| | 13 | 30 0015 | 0.261 | | |
| | 13 | 30 0030 | 0.260 | | |
| 74/09/16 | 13 | 25 0000 | 0.181 | 3.2 | |
| | 13 | 25 0010 | 0.228 | | |
| | 13 | 25 0015 | 0.185 | | |
| | 13 | 25 0031 | 0.198 | | |

ET RETRIEVAL DATE 76/03/16

380802
48 31 21.0 097 55 30.0 4
MATEJCEK LAKE
38099 NORTH DAKOTA

11EPALES 2111202
0030 FEET DEPTH CLASS 00

| DATE FROM TO | TIME OF DAY | DEPTH FEET | 00010 WATER TEMP CENT | 00300 DO MG/L | 00077 TRANSP SECCHI INCHES | 00094 CNDUCTVY FIELD MICROMHO | 00400 PH SU | 00410 T ALK CACO3 MG/L | 00610 NH3-N TOTAL MG/L | 00625 TOT KJEL N MG/L | 00630 NO2&NO3 N-TOTAL MG/L | 00671 PHOS-DIS ORTHO MG/L P |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 74/04/29 | 13 15 | 0000 | 7.9 | | 18 | 280 | 7.70 | 108 | 0.230 | 1.200 | 1.380 | 0.204 |
| | 13 15 | 0005 | 7.9 | 8.2 | | 281 | 7.60 | 114 | 0.260 | 1.100 | 1.320 | 0.215 |
| | 13 15 | 0015 | 6.3 | 8.6 | | 286 | 7.50 | 120 | 0.240 | 1.100 | 1.410 | 0.221 |
| | 13 15 | 0025 | 3.6 | 4.0 | | 337 | 7.40 | 183 | 0.260 | 1.100 | 1.110 | 0.207 |
| 74/07/16 | 13 50 | 0000 | 24.5 | 6.8 | 36 | 522 | 8.30 | 170 | 0.160 | 0.900 | 0.280 | 0.156 |
| | 13 50 | 0005 | 23.1 | 6.8 | | 516 | 8.30 | 169 | 0.150 | 0.800 | 0.230 | 0.160 |
| | 13 50 | 0015 | 17.4 | 1.0 | | 430 | 8.10 | 165 | 0.290 | 1.100 | 0.380 | 0.179 |
| 74/09/16 | 13 50 | 0000 | 14.3 | 7.8 | 15 | 407 | 8.01 | 175 | 0.300 | 1.200 | 0.060 | 0.132 |
| | 13 50 | 0005 | 13.9 | 7.2 | | 395 | 7.99 | 174 | 0.310 | 1.100 | 0.060 | 0.126 |
| | 13 50 | 0015 | 13.7 | 7.4 | | 397 | 8.01 | 173 | 0.310 | 1.100 | 0.060 | 0.119 |
| | 13 50 | 0018 | 13.6 | 7.2 | | 398 | 8.01 | 175 | 0.310 | 1.200 | 0.060 | 0.115 |

| DATE FROM TO | TIME OF DAY | DEPTH FEET | 00665 PHOS-TOT MG/L P | 32217 CHLRPHYL A UG/L | 00031 INCDT LT REMNING PERCENT |
|---|---|---|---|---|---|
| 74/04/29 | 13 15 | 0000 | 0.312 | 1.9 | |
| | 13 15 | 0005 | 0.282 | | |
| | 13 15 | 0015 | 0.277 | | |
| | 13 15 | 0025 | 0.237 | | |
| 74/07/16 | 13 50 | 0000 | 0.206 | 2.7 | |
| | 13 50 | 0005 | 0.184 | | |
| | 13 50 | 0007 | | | 1.0 |
| | 13 50 | 0015 | 0.235 | | |
| 74/09/16 | 13 50 | 0000 | 0.176 | 3.8 | |
| | 13 50 | 0005 | 0.189 | | |
| | 13 50 | 0015 | 0.182 | | |
| | 13 50 | 0018 | 0.191 | | |

# APPENDIX E

# TRIBUTARY DATA

STORET RETRIEVAL DATE 76/03/18

380AA1
48 13 30.0 097 55 30.0 4
MID BRANCH FOREST RIVER
38045 7.5 DAMLEN
C/MATEJCEK RESERVOIR
BELO DAM OFF FAS 481 4.6 M NW OF FORDVIL
11EPALES 2111214
0000 FEET DEPTH CLASS 00

| DATE FROM TO | TIME OF DAY | DEPTH FEET | 00630 NO2&NO3 N-TOTAL MG/L | 00625 TOT KJEL N MG/L | 00610 NH3-N TOTAL MG/L | 00671 PHOS-DIS ORTHO MG/L P | 00665 PHOS-TOT MG/L P |
|---|---|---|---|---|---|---|---|
| 74/09/21 | 09 | 25 | 0.040 | 1.750 | 0.500 | 0.040 | 0.185 |
| 75/05/04 | 10 | 05 | 0.960 | 3.830 | 0.110 | 0.135 | 0.162 |
| 75/05/20 | 10 | 13 | 0.330 | 1.550 | 0.025 | 0.015 | 0.080 |
| 75/06/23 | 10 | 35 | 0.185 | 2.500 | 0.035 | 0.025 | 0.130 |
| 75/07/21 | 10 | 07 | 0.150 | 1.130 | 0.117 | 0.065 | 0.090 |
| 75/08/23 | 09 | 06 | 0.005 | 0.350 | 0.015 | 0.220 | 0.250 |

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ORET RETRIEVAL DATE 76/03/15

380342
48 13 00.0 097 59 25.0 4
MID BRANCH FOREST RIVER
38 7.5 DARLEN
T/MATECUMBE RESERVOIR
BRDG ON SEC RD 2.5 M S OF JCT # FAS 302
11EPALES 21112040
0000 FEET DEPTH CLASS 00

| DATE FROM TO | TIME OF DAY | DEPTH FEET | 00630 NO2&NO3 N-TOTAL MG/L | 00625 TOT KJEL N MG/L | 00610 NH3-N TOTAL MG/L | 00671 PHOS-DIS ORTHO MG/L P | 00665 PHOS-TOT MG/L P |
|---|---|---|---|---|---|---|---|
| 75/05/04 | 10 17 | | 0.960 | 2.400 | 0.195 | 0.135 | 0.220 |
| 75/05/20 | 10 30 | | 0.045 | 0.850 | 0.015 | 0.090 | 0.110 |
| 75/06/23 | 10 55 | | 0.075 | 2.050 | 0.035 | 0.130 | 0.270 |
| 75/07/21 | 10 35 | | 0.010 | 1.850 | 0.025 | 0.180 | 0.320 |
| 75/08/23 | 09 16 | | 0.005 | 1.950 | 0.010 | 0.045 | 0.250 |

STORET RETRIEVAL DATE 76/03/18

380841
48 14 15.0 097 59 05.0 4
UNNAMED CREEK
38 7.5 DAHLEN
T/MATECJEK RESERVOIR
RROG ON SEC RD 1.1 M S OF JCT M FAS 302
11EPALES 2111204
0000 FEET DEPTH CLASS 00

| DATE FROM TO | TIME OF DAY | DEPTH FEET | 00630 NO2&NO3 N-TOTAL MG/L | 00625 TOT KJEL N MG/L | 00610 NH3-N TOTAL MG/L | 00671 PHOS-DIS ORTHO MG/L P | 00665 PHOS-TOT MG/L P |
|---|---|---|---|---|---|---|---|
| 75/05/04 | 10 25 | | 4.900 | 1.850 | 0.070 | 0.045 | 0.080 |
| 75/05/20 | 10 40 | | 0.035 | 1.800 | 0.020 | 0.015 | 0.080 |
| 75/06/23 | 11 00 | | 0.210 | 1.700 | 0.035 | 0.090 | 0.190 |
| 75/07/21 | 10 45 | | 0.005 | 1.450 | 0.020 | 0.025 | 0.140 |

_T RETRIEVAL DATE 76/03/18

38081C
48 10 50.0 097 54 35.0 4
S BRANCH FOREST RIVER
38099 7.5 DAHLEN
T/MATECJEK RESERVOIR
BRDG ON SEC RD 2 MI NNE OF DAHLEN
11EPALES 2111204
0000 FEET DEPTH CLASS 00

| DATE FROM TO | TIME OF DAY | DEPTH FEET | 00630 NO2&NO3 N-TOTAL MG/L | 00625 TOT KJEL N MG/L | 00610 NH3-N TOTAL MG/L | 00671 PHOS-DIS ORTHO MG/L P | 00665 PHOS-TOT MG/L P |
|---|---|---|---|---|---|---|---|
| 75/05/04 | 10 55 | | 3.800 | 1.850 | 0.120 | 0.090 | 0.110 |
| 75/05/20 | 10 00 | | 0.010 | 1.700 | 0.025 | 0.155 | 0.170 |
| 75/06/23 | 10 30 | | 0.045 | 2.000 | 0.050 | 0.390 | 0.480 |
| 75/07/21 | 11 48 | | 0.005 | 2.000 | 0.030 | 0.105 | 0.280 |